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LAC LA NONNE

Alberta
ENVIRONMENT
Water Quality Control Branch
Pollution Control Division

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Water Quality Control Branch of Alberta Environment.

As you read through the brochure, you may find you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics.** Refer to this for further interpretation.

Brochures are available for the following lakes:

- Sandy Lake
- Lac La Nonne
- Wizard Lake
- Pine Lake
- Garner Lake
- Skeleton Lake
- Lac La Biche
- Nakamun Lake
- Wabamun Lake

FEBRUARY, 1985

Lac La Nonne is located 85 km northwest of Edmonton, straddling the boundary between the counties of Lac Ste. Anne and Barrhead There is public access, with a boat launch, within the Lac La Nonne subdivision.

The lake is deepest (20 m or 65 ft) at its northern end (see depth contour map). The southern end has a maximum depth of 9 m (30 feet). This end has shallow areas and islands compared with the northern end, which drops off sharply. The outlet, called MacDonald Creek, is located in the extreme northern corner of the lake. It flows to the Pembina River.

The lake contains northern pike, yellow perch, walleye, tullibee, and whitefish. It is not fished commercially.

The drainage area of Lac La Nonne is large compared to the lake's volume. This drainage area to lake volume ratio is greater than that of most lakes in the region. The high ratio suggests a very fertile or eutrophic lake, since the large land area contributes a high nutrient supply. This is offset somewhat by the two other lakes within La Nonne's drainage area, Majeau and Nakamun. They act as nutrient traps for the land surrounding them. Although there is a regular flow from Majeau toward La Nonne, Nakamun and its drainage area should probably be excluded from La Nonne's watershed since the creek between Nakamun and La Nonne rarely flows.

As the watershed map shows, about half of Lac La Nonne's immediate* watershed has been cleared for agriculture. This cleared portion theoretically contributes five times more phosphorus than the portion in natural bush. A 1981 study**, in which the nutrient supply was actually measured, confirmed this figure.

Many people assume that sewage from cottages is a major contributor to problems with algae and weeds. Yet, as the table shows, maximum possible supply of phosphorus from sewage (see explanation of THEORETICAL PHOSPHORUS SUPPLY, p.10) is only about 8 per cent of the total supply.

The areal loading figure indicates the lake should be very eutrophic because the phosphorus supply per square metre of lake surface is high compared to other lakes.

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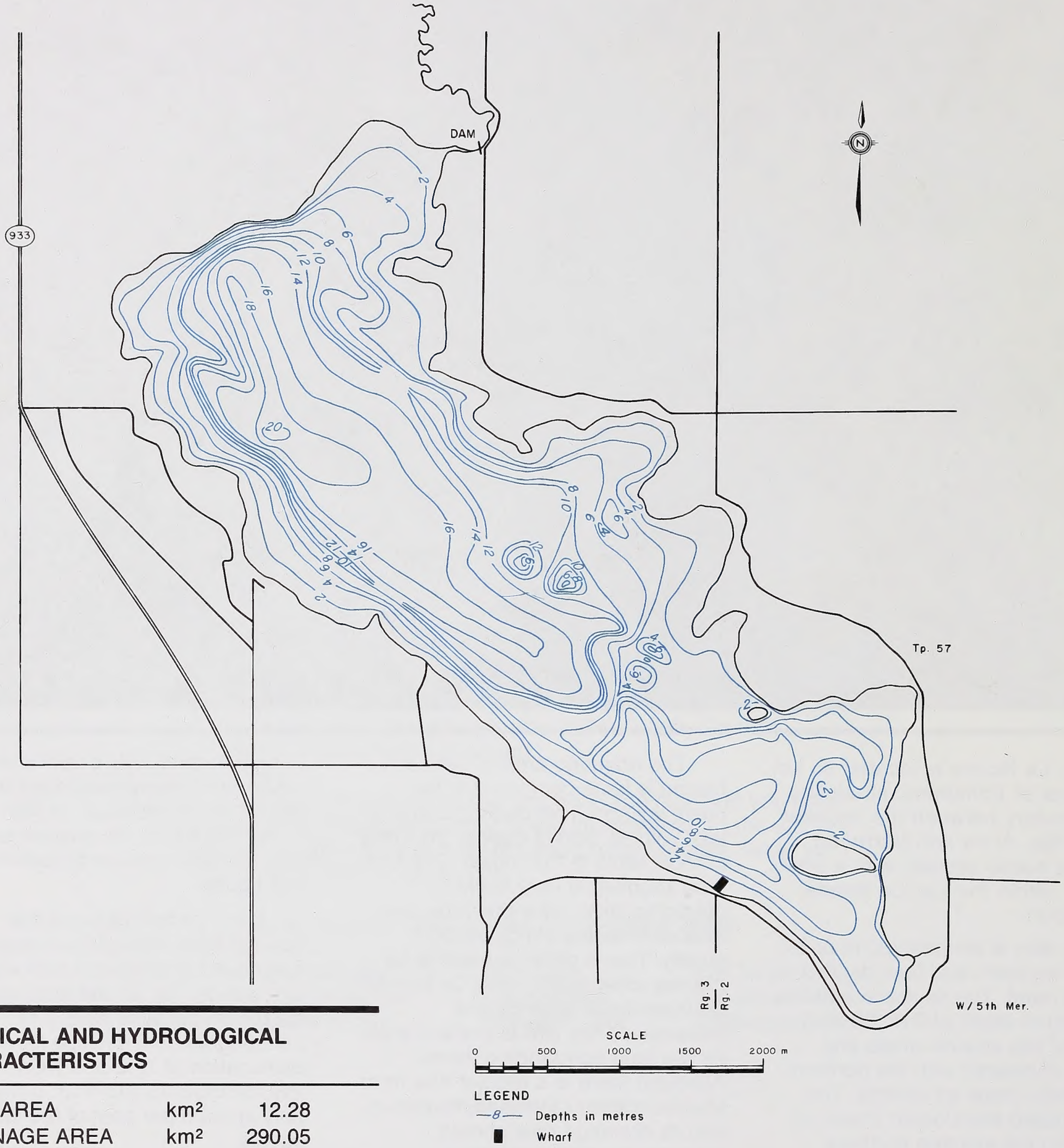
* excluding the land surrounding Majeau and Nakamun Lakes.

** "Assessment of phosphorus export from the Majeau Creek Watershed Lac La Nonne" Water Quality Control Branch, Alberta Environment.

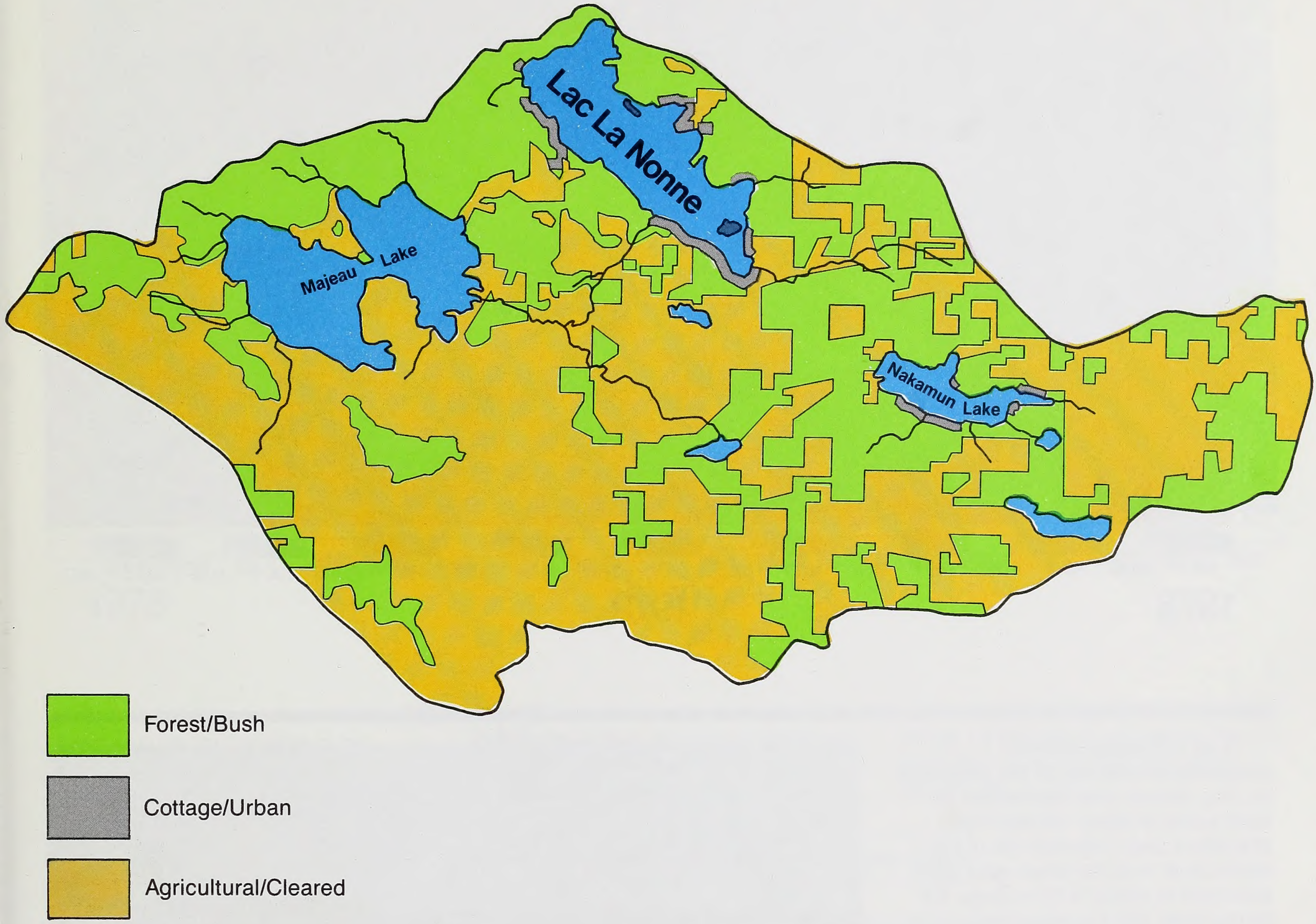
Depth Contour Map



PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

LAKE AREA	km²	12.28
DRAINAGE AREA (excluding lake)	km²	290.05
DRAINAGE AREA/ LAKE VOLUME		3.
VOLUME	m³	92.956×10^6
MAXIMUM DEPTH	m	20.
MEAN DEPTH	m	7.57
INFLOW	m³	14.241×10^6
RESIDENCE TIME	years	6.5

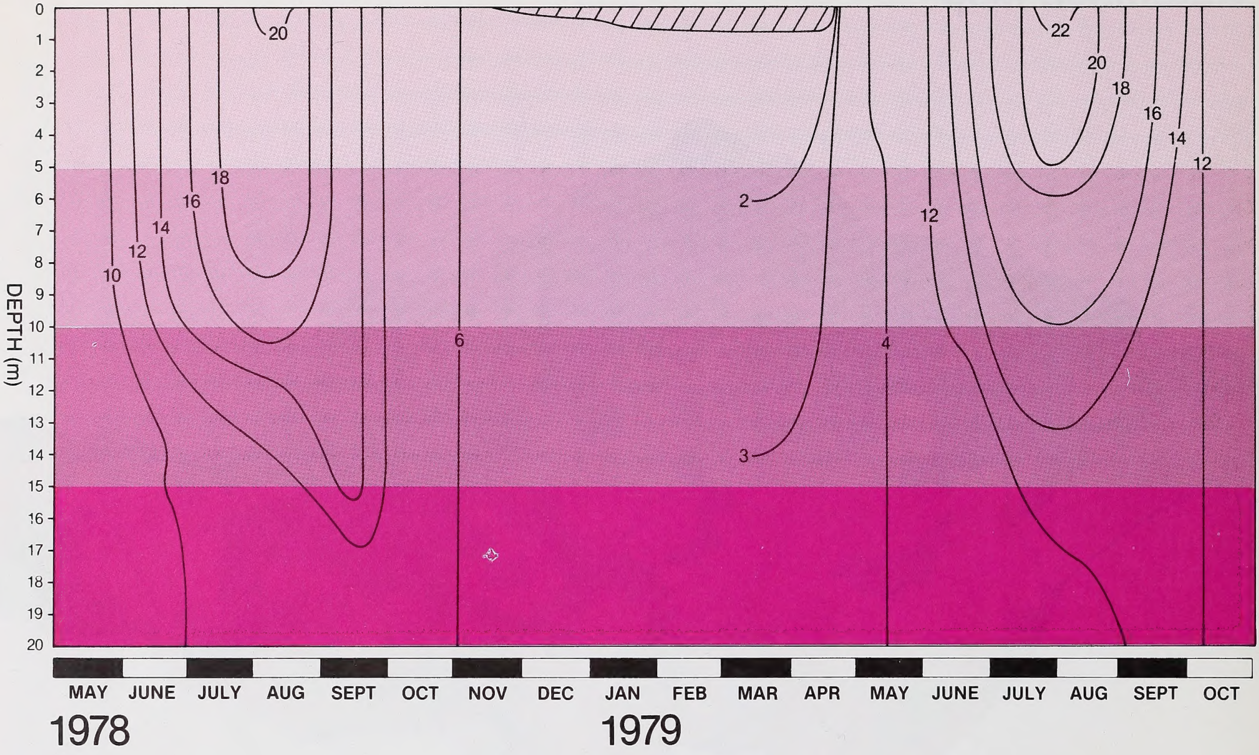
Lac La Nonne Watershed Map



THEORETICAL PHOSPHORUS SUPPLY, kg/year

Surface Run-off:	
Forested/Bush	537.
Agricultural/Cleared	2,770.
Cottage/Urban	160.
Precipitation, Dustfall	377.
Input via Majeau Lake	1,130.
Input via Nakamun Lake	524.
Sewage from all cottages and camps	484.
TOTAL	5,982.
Areal loading, g/m² of lake surface	0.49

Temperature (°C)

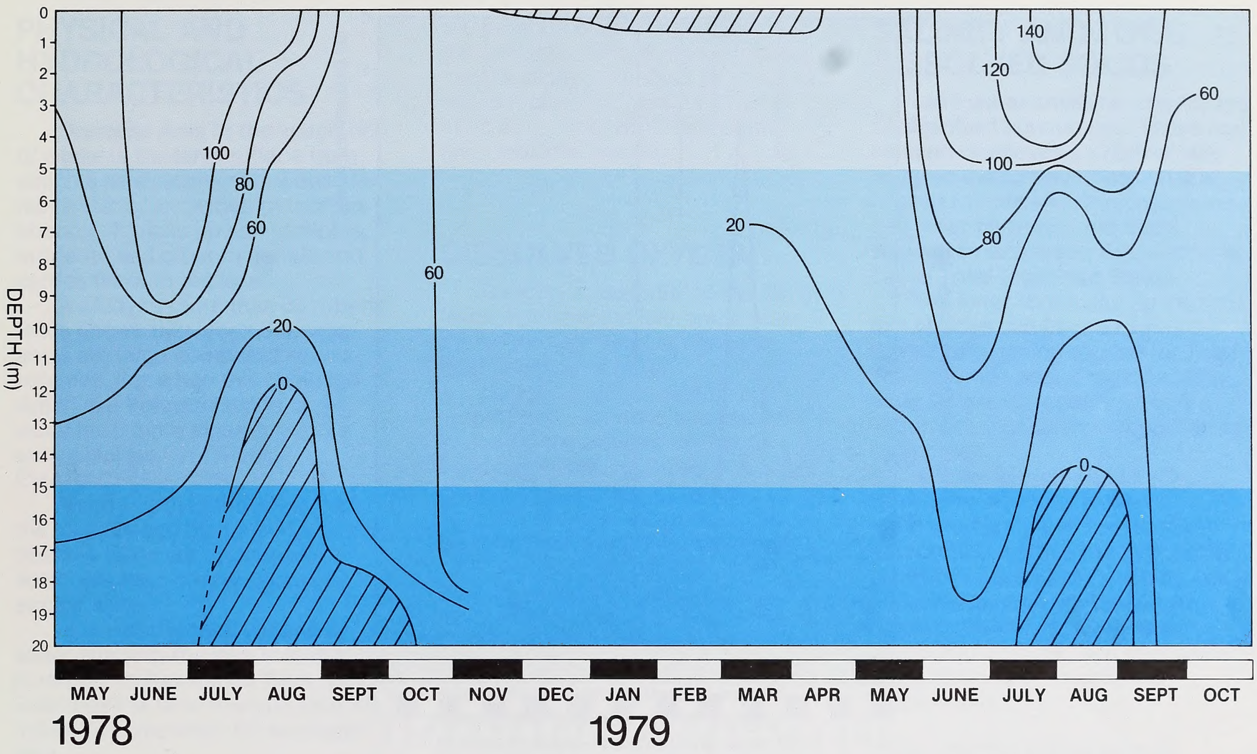


Lac La Nonne showed temperature layering at the deep end in July, August and September of both years studied. Usually the boundary area between the upper warm layer and the lower cool layer occurred at about 9-10 m deep. By September, this boundary area had dropped to 14 or 15 m. The lake mixed completely in October as the water cooled and boundary between the layers broke down.

There was not enough oxygen in the lower layer of the deep northern end to support fish in July, August and most of September. On the other hand, the water was supersaturated with oxygen in the upper layers during the days as a result of algal photosynthesis.

At the shallower southeastern end, this layering effect did not take place. But the center of the lake was

Dissolved Oxygen (% Saturation)

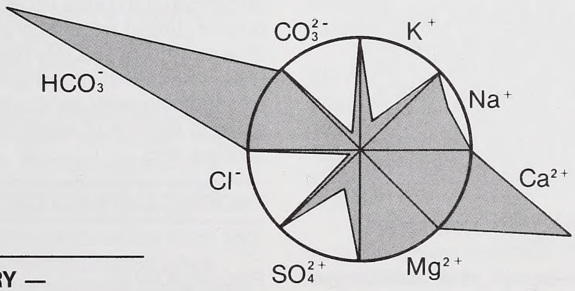


deep enough for layering to be periodically established and disrupted, coinciding with calm and windy periods respectively. This has important implications for the fertility of the lake, since phosphorus from the sediments moves into the water when oxygen is low.

In winter under ice, oxygen was depleted below about 10 m. Since Lac La Nonne is fairly deep, the risk of winterkill is probably low. However, if ice should form after a calm period in the fall, so that the lake mixed poorly, the potential for winterkill would increase.

The ions of calcium (Ca) and bicarbonate (HCO_3) dominate the water chemistry of Lac La Nonne. This is typical of most Alberta lakes. Total dissolved solids and salinity are low. The range of pH is wide, because the deep, unoxygenated bottom layer has pH values as low as 7 while the upper layer might have a pH over 9. In general, the chemistry of Lac La Nonne is well within the favorable range for fish and other aquatic life.

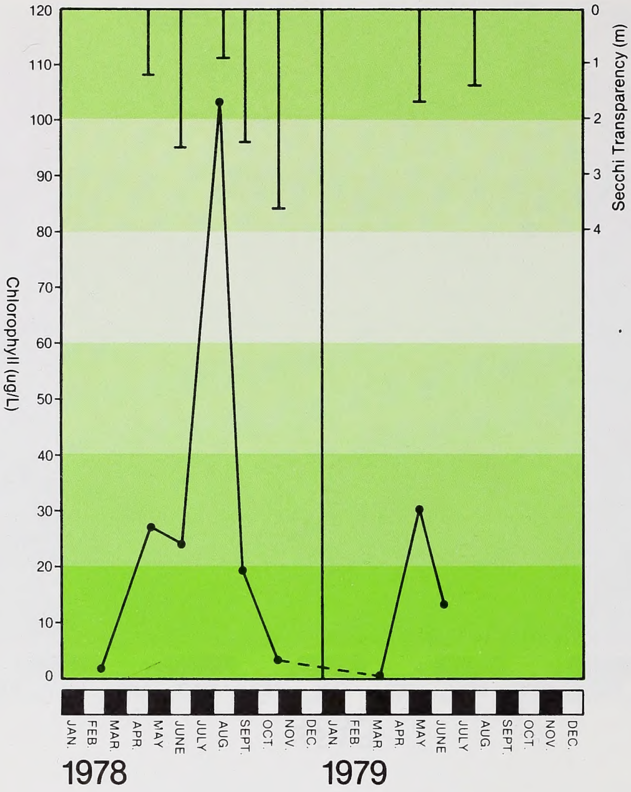
IONIC DIAGRAM — Relative proportions of ions



CHEMISTRY — ice-free season averages

		1978	1979
TOTAL SALINITY	meq/L	6.	6.
pH (range)		7.6 - 8.8	7.0 - 9.2
ALKALINITY	mg/L	133.	131.
TOTAL DISSOLVED SOLIDS	mg/L	158.	154.

Trophic Status



Lac La Nonne is highly eutrophic. Dense blue-green algal blooms are common in summer. Summer fish kills may occur. Water clarity is very poor during periods of dense algae.

As the graph shows, levels of chlorophyll (and therefore algae) were greater in 1978 than in 1979. This may be related to weather cycles since other lakes in the Edmonton area also had higher chlorophyll in 1978 than in 1979. The peak value in August of 1978 of over 100 µg/L was collected during an intense algal bloom.

The chlorophyll peak in 1979 occurred later in the summer than in 1978, so that by the last sampling date, in October, 1979, algae was still abundant in the lake.

The shallow end of the lake tended to have slightly more algae in the water than the deep end, although in October after mixing the reverse was true. The alternating periods of layering and mixing allow phosphorus to build up near the bottom during periods of low oxygen. This is then mixed into the upper water, supplying growing algae. Also, strong north-west winds might blow surface blooms of algae to the shallow end.

There are several reasons why Lac La Nonne is so fertile. The watershed is large, and much of it in the Majeau Creek area is used for cattle production. Nutrients that might remain trapped in the bottom mud are recycled into the water when oxygen near the bottom is used in the decomposition of algae and other life.

TROPHIC CHARACTERISTICS — ice-free season averages

		1978	1979
PHOSPHORUS	ug/L	246.	192.
NITROGEN	mg/L	2.32	2.30
CHLOROPHYLL	ug/L	36.	31.
SECCHI (transparency)	m	2.1	1.6

TOTAL NUMBERS OF BENTHIC ORGANISMS	3,261/m²
Oligochaeta	34% of total
Chironomidae	55% of total

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake volumes, (i.e. when this **Drainage Area/Lake Volume** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar size.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time,** which indicates the time it would take the inflow to completely fill an empty lake.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom. Because this colder water is denser, it resists mixing into the warmer, lighter upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom from wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4°) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

The diagram(s) show temperature at each depth over the annual cycle. Similar temperatures over time are connected by lines called isotherms. Vertical lines indicate mixing, while horizontal lines indicate layering.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. It enters the lake water from the air through wind action, and plant photosynthesis.

Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts toward consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (Fish are stressed when oxygen falls below about 20% saturation — shown in red on the diagram). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens during an algal bloom on calm nights.

The diagram shows oxygen saturation at each depth over the annual cycle. Similar saturations over time are connected by lines called isopleths. Vertical lines indicate uniform saturation from top to bottom, while horizontal lines indicate stagnation near the bottom.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids.**

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

*Ions: Chemical form in water of constituents such as sodium and carbonate.

PH AND ALKALINITY

The pH of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral — neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic.** Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic.** In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits the recreational use of the lake. Lake users consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status.**

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/ Parkland areas of Alberta range between 10 and 120 ug/L, or oligotrophic to highly eutrophic, and nitrogen ranges between 0.5 and 3.5 mg/L.

Transparency declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disc,** which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the Secchi transparency.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll,** the green photosynthetic pigment.

The number of animals living in the bottom mud of the lake also may indicate its fertility. **Oligochaeta** are tiny worms; **Chironomidae** are immature stages of a fly called a midge.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply of all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North American, the quantity of phosphorus contributed by a hectare of forest is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in the Baptiste Lake watershed.

In all studies, the phosphorus supply from cleared or agricultural land was greater than that from forest, averaging 5 times more.

The "theoretical" phosphorus supply is estimated, without actually measuring it, by multiplying phosphorus supply factors for each type of land use by the area of that land use.

Similar factors are used for the supply from precipitation. The supply from sewage assumes that all sewage enters the lake, since it is nearly impossible to measure this source in lakes. Therefore, the number reported represents the maximum possible supply from that source.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

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